CSE 241 Lecture 1

Adopted from the lecture slides of the book:
Absolute C++ by Walter Savitch, Kenrick Mock

C++ Basics

- Introduction to C++
  - Origins, Object-Oriented Programming, Terms
- Variables, Expressions, and Assignment Statements
- Console Input/Output
- Program Style
- Libraries and Namespaces

Introduction to C++

- C++ Origins
  - Low-level languages
    - Machine, assembly
  - High-level languages
    - C, C++, ADA, COBOL, FORTRAN
  - Object-Oriented-Programming in C++
- C++ Terminology
  - *Programs* and *functions*
  - Basic Input/Output (I/O) with **`cin`** and **`cout`**

A Sample C++ Program

```cpp
#include <iostream>
using namespace std;

int main()
{
    int numberOfLanguages;
    cout << "Hello reader.\n"
        << "Welcome to C++.\n";
    cout << "How many programming languages have you used? ";
    cin >> numberOfLanguages;

    if (numberOfLanguages < 1)
        cout << "Read the preface. You may prefer\n"
        << "a more elementary book by the same author.\n";
    else
        cout << "Enjoy the book.\n";
        return 0;
}
```

Sample Output 1

```
Hello reader.
Welcome to C++.
How many programming languages have you used? 0
Read the preface. You may prefer
a more elementary book by the same author.
```

Sample Output 2

```
Hello reader.
Welcome to C++.
How many programming languages have you used? 1
Enjoy the book
```

C++ Variables

- C++ Identifiers
    - Keywords/reserved words vs. Identifiers
    - Case-sensitivity and validity of identifiers
    - Meaningful names!
- Variables
    - A memory location to store data for a program
    - Must declare all data before use in program

Simple Types

TYPE NAME	MEMORY USED	SIZE RANGE	PRECISION
short (also called short int)	2 bytes	-32,768 to 32,767	Not applicable
int	4 bytes	-2,147,483,648 to 2,147,483,647	Not applicable
long (also called long int)	4 bytes	-2,147,483,648 to 2,147,483,647	Not applicable
float	4 bytes	approximately 10^{-38} to 10^{38}	7 digits
double	8 bytes	approximately 10^{-308} to 10^{308}	15 digits
char	1 byte	All ASCII characters (Can also be used as an integer type, although we do not recommend doing so.)	Not applicable
bool	1 byte	true, false	Not applicable

C++11 Fixed Width Integer Types

TYPE NAME	MEMORY USED	SIZE RANGE
int8_t	1 byte	-128 to 127
uint8_t	1 byte	0 to 255
int16_t	2 bytes	-32,768 to 32,767
uint16_t	2 bytes	0 to 65,535
int32_t	4 bytes	-2,147,483,648 to 2,147,483,647
uint32_t	4 bytes	0 to 4,294,967,295
int64_t	8 bytes	-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
uint64_t	8 bytes	0 to 18,446,744,073,709,551,615
long long	At least 8 bytes	

New C++11 Types

- **`auto`**
  - Deduces the type of the variable based on the expression on the right side of the assignment statement

```
auto x = expression;
```

  - More useful later when we have verbose types
- **`decltype`**
  - Determines the type of the expression. In the example below, **`x*3.5`** is a **`double`** so **`y`** is declared as a **`double`**.

```
decltype(x*3.5) y;
```

Assigning Data

- Initializing data in declaration statement
    - Results "undefined" if you don't!

```
int myValue = 0;
```

- Assigning data during execution
    - Lvalues (left-side) & Rvalues (right-side)
        - Lvalues must be variables
        - Rvalues can be any expression

```
distance = rate * time;
```

- Lvalue: "distance"
- Rvalue: "rate * time"

Assigning Data: Shorthand Notations

EXAMPLE	EQUIVALENT TO
count += 2;	count = count + 2;
total -= discount;	total = total - discount;
bonus *= 2;	bonus = bonus * 2;
time /= rushFactor;	time = time / rushFactor;
change %= 100;	change = change % 100;
amount *= cnt1 + cnt2;	amount = amount * (cnt1 + cnt2);

Data Assignment Rules

- Compatibility of Data Assignments
  - Type mismatches
    - General Rule: Cannot place value of one type into variable of another type
- **`intVar = 2.99;  // 2 is assigned to intVar!`**
  - Only integer part "fits", so that's all that goes
  - Called "implicit" or "automatic type conversion"
- Literals
  - **`2, 5.75, "Z", "Hello World"`**
  - Considered "constants": can't change in program

Literal Data

- Literals
  - `2               // Literal constant int`
  - `5.75            // Literal constant double`
  - `"Z"             // Literal constant char`
  - `"Hello World"  // Literal constant string`
- Cannot change values during execution
- Called "literals" because you "literally typed" them in your program!

Escape Sequences

- "Extend" character set
- Backslash, \ preceding a character
    - Instructs compiler: a special "escape character" is coming
    - Following character treated as "escape sequence char"

SEQ	MEANING
`\n`	New line
`\r`	Carriage return (Positions the cursor at the start of the current line. You are not likely to use this very much.)
`\t`	(Horizontal) Tab (Advances the cursor to the next tab stop.)
`\a`	Alert (Sounds the alert noise, typically a bell.)
`\\`	Backslash (Allows you to place a backslash in a quoted expression.)
`\'`	Single quote (Mostly used to place a single quote inside single quotes.)
`\"`	Double quote (Mostly used to place a double quote inside a quoted string.)
`\v`	Vertical tab
`\b`	Backspace
`\f`	Form feed
`\?`	Question mark

Raw String Literals

- Introduced with C++11
- Avoids escape sequences by literally interpreting everything in parentheses

```
string s = R"(\t\\t\n)";
```

- The variable s is set to the exact string **`"\t\\t\n"`**
- Useful for filenames with **`\`** in the file path

Constants

- Naming your constants
  - Literal constants are "OK", but provide little meaning
    - e.g., seeing **24** in a code, tells nothing about what it represents
- Use named constants instead
  - Meaningful name to represent data

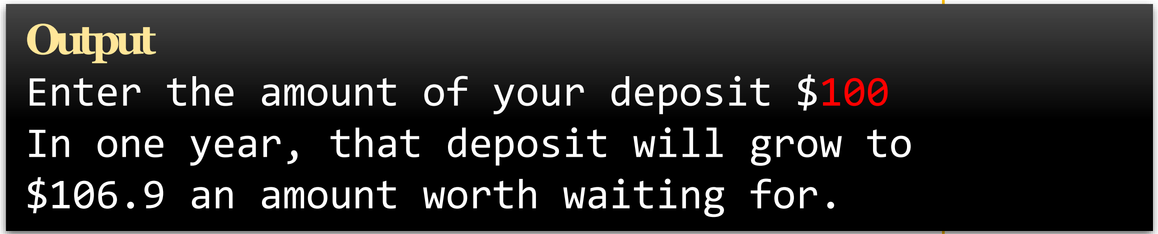
```
const int NUMBER_OF_STUDENTS = 24;
```

  - Called a "declared constant" or "named constant"
  - Now use its name wherever needed in program
  - Added benefit: changes to value result in one fix

Example

```cpp
#include <iostream>
using namespace std;

int main( )
{
    const double RATE = 6.9;
    double deposit;
    cout << "Enter the amount of your deposit $";
    cin >> deposit;
    double newBalance;
    newBalance = deposit + deposit*(RATE/100);
    cout << "In one year, that deposit will grow to\n"
         << "$" << newBalance << " an amount worth waiting for.\n";
    return 0;
}
```



Output

```
Enter the amount of your deposit $100
In one year, that deposit will grow to
$106.9 an amount worth waiting for.
```

Arithmetic Precision

- Precision of Calculations
  - VERY important consideration!
    - Expressions in C++ might not evaluate as you’d "expect"!
  - "Highest-order operand" determines type of arithmetic "precision" performed
  - Common pitfall!

Arithmetic Precision Examples

- **`17 / 5`** evaluates to **`3`** in C++!
  - Both operands are integers
  - Integer division is performed!
- **`17.0 / 5`** equals **`3.4`** in C++!
  - Highest-order operand is "**`double`** type"
  - **`double`** "precision" division is performed!
- **`int intVar1 =1, intVar2=2;`**
  `intVar1 / intVar2;`
  - Performs integer division!
  - Result: **`0`**!

Individual Arithmetic Precision

- Calculations done "one-by-one"
  - `-1 / 2 / 3.0 / 4` performs 3 separate divisions.
    - First: `1 / 2` equals `0`
    - Then: `0 / 3.0` equals `0.0`
    - Then: `0.0 / 4` equals `0.0`!
- So not necessarily sufficient to change just "one operand" in a large expression
  - Must keep in mind all individual calculations that will be performed during evaluation!

Type Casting

- Casting for Variables
  - Can add "**`.0`**" to literals to force precision arithmetic, but what about variables?
    - We can’t use "**`myInt.0`**"!
  - **`static_cast<double>intVar`**
  - Explicitly "casts" or "converts" **`intVar`** to **`double`** type
    - Result of conversion is then used
    - Example expression:

      ```
      doubleVar = static_cast<double>intVar1 / intVar2;
      ```

      - Casting forces double-precision division to take place among two integer variables!

Type Casting

- Two types
  - Implicit—also called "Automatic"
    - Done *for* you, automatically
      `17 / 5.5`
      This expression causes an "implicit type cast" to take place, casting the **`17`** to **`17.0`**
  - Explicit type conversion
    - Programmer specifies conversion with cast operator
      `(double)17 / 5.5`
      Same expression as above, using explicit cast
      `(double)myInt / myDouble`
      More typical use; cast operator on variable

Shorthand Operators

- Increment & Decrement Operators
  - Just short-hand notation
  - Increment operator, **`++`**
    `intVar++;` is equivalent to **`intVar = intVar + 1;`**
  - Decrement operator, **`--`**
    `intVar--;` is equivalent to **`intVar – 1;`**
- Post-Increment **`intVar++`**
  - Uses current value of variable, THEN increments it
- Pre-Increment **`++intVar`**
  - Increments variable first, THEN uses new value
- "Use" is defined as whatever "context" variable is currently in
- No difference if "alone" in statement:
  `intVar++;` and **`++intVar;`** --> identical result

Post-Increment and Pre-Increment in Action

```
int   n = 2,
valueProduced;
 valueProduced = 2 * (n++);
 cout << valueProduced << endl;
 cout << n << endl;
```

output:

```
 4
  3
```

Since post-increment was used

```
int   n = 2,
valueProduced;
 valueProduced = 2 * (++n);
 cout << valueProduced << endl;
 cout << n << endl;
```

output:

```
6
 3
```

Since pre-increment was used

Console Input/Output

- I/O objects **`cin`**, **`cout`**, **`cerr`**
- Defined in the C++ library called **`<iostream>`**
- Must have these lines (called pre-processor directives) near start of file:

  ```
  #include <iostream>
  using namespace std;
  ```

- Tells C++ to use appropriate library so we can use the I/O objects **`cin`**, **`cout`**, **`cerr`**

Console Output

- What can be outputted?
  - Any data can be outputted to display screen
    - Variables
    - Constants
    - Literals
    - Expressions (which can include all of above)
  - **`cout << numberOfGames << " games played.";`**
    2 values are outputted:
    - "value" of variable **`numberOfGames`**, literal string " **`games played.`**"
- Cascading: multiple values in one **`cout`**

Separating Lines of Output

- New lines in output
  - Recall: **`"\n"`** is escape sequence for the **`char`** "newline"
- A second method: object **`endl`**
- Examples:
  - **`cout << "Hello World\n";`**
    Sends string **`"Hello World"`** to display, & escape sequence **`"\n"`**, skipping to next line
  - **`cout << "Hello World" << endl;`**
    Same result as above

String type

- C++ has a data type of **`string`** to store sequences of characters
  - Not a primitive data type; distinction will be made later
  - Must add **`#include <string>`** at the top of the program
  - The “**`+`**” operator on strings concatenates two strings together
  - **`cin >> str`** where **`str`** is a **`string`** only reads up to the first whitespace character

Input/Output

```cpp
#include <iostream>
#include <string>
using namespace std;
int main( )
{
    string dogName;
    int actualAge;
    int humanAge;
    cout << "How many years old is your dog?" << endl;
    cin >> actualAge;
    humanAge = actualAge * 7;
    cout << "What is your dog's name?" << endl;
    cin >> dogName;
    cout << dogName << "'s age is approximately " <<
         "equivalent to a " << humanAge << " year old human."
         << endl;
    return 0;
}
```

Sample Output 1

```
How many years old is your dog?
5
What is your dog's name?
Necmi
Necmi's age is approximately equivalent to a 35 year old human.
```

Sample Output 2

```
How many years old is your dog?
10
What is your dog's name?
Mr. Bojangles
Mr.'s age is approximately equivalent to a 70 year old human.
```

`"Bojangles"` is not read into **`dogName`** because **`cin`** stops input at the space.

Formatting Output

- Formatting numeric values for output
  - Values may not display as you'd expect!

    ```
    cout << "The price is $" << price << endl;
    ```

    - If **`price`** (declared **`double`**) has value **`78.5`**, you might get:
      - **`The price is $78.500000`** or:
      - **`The price is $78.5`**
- We must explicitly tell C++ how to output numbers in our programs!

Formatting Numbers

- "Magic Formula" to force decimal sizes:

```
cout.setf(ios::fixed);
cout.setf(ios::showpoint);
cout.precision(2);
```

- These statements force all future "**cout**’ed" values:
  - To have exactly two digits after the decimal place
  - Example:

    ```
    cout << "The price is $" << price << endl;
    ```

  - Now results in the following:

    ```
    The price is $78.50
    ```

- Can modify precision "as you go" as well!

Error Output

- Output with **`cerr`**
  - **`cerr`** works same as **`cout`**
  - Provides mechanism for distinguishing between regular output and error output
- Re-direct output streams
  - Most systems allow **`cout`** and **`cerr`** to be "redirected" to other devices
    - e.g., line printer, output file, error console, etc.

Input Using `cin`

- **`cin`** for input, **`cout`** for output
- Differences:
- "**`>>`**" (extraction operator) points opposite
  - Think of it as "pointing toward where the data goes"
  - Object name "**`cin`**" used instead of "**`cout`**"
  - No literals allowed for **`cin`**
    - Must input "to a variable"
- **`cin >> num;`**
  - Waits on-screen for keyboard entry
  - Value entered at keyboard is "assigned" to **`num`**

Prompting for Input: **`cin`** and **`cout`**

- Always "prompt" user for input

```
cout << "Enter number of dragons: ";
 cin >> numOfDragons;
```

  - Note no **`"\n"`** in **`cout`**. Prompt "waits" on same line for keyboard input as follows:

```
Enter number of dragons: ____
```

  - Underscore above denotes where keyboard entry is made
- Every **`cin`** should have **`cout`** prompt
  - Maximizes user-friendly input/output

Program Style

- Bottom-line: Make programs easy to read and modify
- Comments, two methods:
  - **`// Two slashes indicate entire line is to be ignored`**
  - **`/*Delimiters indicates everything between is ignored*/`**
  - Both methods commonly used
- Identifier naming
  - `ALL_CAPS` for constants
  - `lowerToUpper` for variables
  - Most important: MEANINGFUL NAMES!

Libraries

- C++ Standard Libraries
- **`#include <Library_Name>`**
  - Directive to "add" contents of library file to your program
  - Called "preprocessor directive"
    - Executes before compiler, and simply "copies" library file into your program file
- C++ has many libraries
  - Input/output, math, strings, etc.

Namespaces

- Namespaces defined:
  - Collection of name definitions
- For now: interested in namespace "**`std`**"
  - Has all standard library definitions we need
- Examples:

```
 #include <iostream>
  using namespace std;
```

  - Includes entire standard library of name definitions

-
  ```
  #include <iostream>
  using std::cin;
  using std::cout;
  ```
  - Can specify just the objects we want